

Investigation of the Excited State Iodine Lifetime in the Photodissociation of Perfluoroalkyl Iodides

by

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The development of a space-based solar pumped laser system has been the focus of NASA research for several years. This laser would have application in power transmission to space vehicles and bases on the moon or Mars, where it could provide a means of electric power generation, propulsion, and communication[1]. An evaluation of prospective laser materials over the past decade has resulted in the identification of the iodine photodissociation laser as that system best suited to solar-pumped high energy operation[2]. The active medium for the solar-pumped iodine photodissociation laser is from the family of perfluoroalkyl iodides. These lasants have the general form $C_nF_{2n+1}I$, often abbreviated as RI. These iodides are known to exhibit photodissociation of their C-I bond when irradiated by near UV photons. Though many isomers have been tested with regard to their solar pumping properties, the iodide $t-C_4F_9I$ has been identified as the most promising material for high-power application.

C_4F_9I is an attractive candidate for a lasant in that: 1) its absorption curve is shifted toward longer wavelengths in comparison to other iodides, allowing a greater absorption of the available solar radiation, and 2) the formation of R_2 dimers appears to be greatly limited. This subsequently results in greater recombination to the original RI molecule and a decreased production of the iodine molecule I_2 , which is known to inhibit lasing action.

The excited state lifetime of the active medium is a very important parameter in a laser system. It governs the ability of a laser amplifier to store energy. The excited iodine atom has a long natural radiative lifetime (130 msec), giving the potential for high gain in the laser system[3]. However, non-radiative processes such as quenching by the parent RI molecule can shorten the lifetime considerably. If the lifetime is reduced too severely, the material ceases to be an effective lasant. Therefore, when attempting to develop theoretical models to

assess the performance of a potential laser system, knowledge of the excited state lifetime is of prime importance.

The focus of this work is to experimentally determine the lifetime of the excited iodine atom following photodissociation of C_4F_9I , and also to monitor fluorescence from the iodine molecule at 500 nm to determine if I_2 is being produced in the process. Photodissociation is achieved using a XeCl excimer laser with output wavelength of 308 nm. The XeCl beam is focused into the middle of a cylindrical quartz cell containing the lasant. The laser pulse is detected with a fast risetime photomultiplier tube (PMT) as it exits the cell. Fluorescence is recorded at 90 degrees to the XeCl beam by detection with a germanium photodiode fronted by a 1.315 micron filter to allow transmission of fluorescence due to excited atomic iodine only. The exponentially decaying fluorescence signal is measured to determine the time required for its intensity to fall to 1/e of its initial value. This time represents the lifetime of the excited iodine atom for a given pressure of RI vapor. Fluorescence from molecular iodine is also monitored at 90 degrees to the laser beam by a PMT fronted by a 500nm transmission filter. These experiments will be conducted at various pressures of RI to record any changes in lifetime versus pressure.

Work to date consists of experimental design, equipment acquisition and assembly, and initial checkout. The experiment is being brought on-line using the less expensive and readily available iodide C_3F_7I . Once completely operational, C_4F_9I will be inserted as the sample lasant.

References

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